

SPECIFICATIONS

MAIN LIBRARY HVAC REPAIRS

**585 Franklin Street
Mountain View, CA 94041**

PROJECT SUMMARY

The project consists of modifying the existing HVAC controls, includes the room pressure control, carbon dioxide control and new variable frequency drives.

GENERAL PROVISIONS

1. PREVAILING WAGE REQUIREMENTS

This is not a prevailing wage project. Department of Industry prevailing wage requirements will not apply to this project.

2. RESPONSIBILITIES OF THE CONTRACTOR

The City assumes no responsibility for loss of or damage to materials or equipment owned or operated by the contractor, his agents or employees. All work damaged due to vandalism or any other cause prior to acceptance of the work by the City shall be repaired or replaced by the contractor at the contractor's own expense.

The contractor shall comply with all applicable State and local laws, ordinances, codes and regulations. All safety orders, rules and recommendations of the Division of Industrial Relations of the State of California, applicable to all the work performed under this contract, shall be obeyed and enforced by the contractor. The contractor shall be solely responsible for any and all injuries to individuals or properties resulting directly or indirectly from the contractor's performance of the work, and the contractor agrees to indemnify and hold the City free and harmless from and against any and all liabilities, expenses, claims, costs, suits and damages arising out of the negligence or on the part of the contractor.

3. WORKING HOURS

The regular working hours for the City are 8:00 a.m. to 4:00 p.m., Monday through Friday. Work on weekends may be allowed with prior approval.

4. SITE APPEARANCE

The contractor shall maintain a neat appearance to the work site throughout the construction period. Debris generated by the construction shall be disposed of concurrently with its removal. If stockpiling is necessary, the material shall be removed or disposed of daily or at the direction of the Facilities Project Manager.

If the contractor damages any improvements, the contractor shall repair or replace the damaged improvements to the satisfaction of the Facilities Project Manager. The repair or replacement work shall be of equal or greater quality and in appearance to prior condition. The repair or replacement method used shall be approved by the Facilities Project Manager.

The contractor shall be solely responsible for and bear the costs of repairing or replacing damaged improvements. Excess materials generated from the repair or replacement work shall be disposed of off-site by the contractor at the contractor's own expense.

5. DISPOSAL OF MATERIALS

Any damaged equipment needing removal is to be disposed of off-site in a legal manner. The contractor shall not stockpile debris, rubbish, garbage, excess materials or other unwanted materials on the sidewalk or on the street. All demolition rubble, debris, slurry, dirt, trees, shrubs, vegetation and other excess materials resulting from the contractor's operations shall be disposed of off-site in a safe and legal manner at the contractor's own expense. All rubble, debris or other excess materials must be removed at the end of each workday. Washing of excess materials into the storm drain is prohibited.

Payment for transportation and disposal of excess materials and removed equipment shall be considered as included in the contract, and no additional compensation shall be made therefor.

6. SITE CLEANUP

If the contractor fails to perform the final cleanup work to the satisfaction of the Facilities Project Manager, the City will withhold the final payment until the contractor complies with the requirements. If the final cleanup is deemed unsatisfactory, the contractor shall remedy the work within two (2) working days after receipt of rejection notice from the City. If the contractor fails to remedy the work as directed, the City may, at its own option, hire a third party to perform the work and deduct the cost of the cleanup work from the final payment due the contractor.

7. INSURANCE REQUIREMENTS

Follow the requirements from the Purchasing Division under "Instruction for Submitting Bids."

8. CHANGE ORDER

Contractor shall secure prior approval from the Facilities Project Manager and Purchasing Division for any change orders which may impact project price and schedule. The contractor agrees to waive his/her rights of any claim if any out-of-scope work is carried out without an approved change order signed by the Facilities Project Manager of the City. If the owner initiates a change order, a detailed cost breakdown proposal shall be submitted within six (6) calendar days for owner's approval. Contractor shall verify all code requirements and include these requirements in the total price. The changes, if any, caused by Building Code requirements will not qualify for a cost change order.

When field changes, clarifications or other information regarding changes to the contractor's work become necessary, a letter will be issued to the contractor notifying the contractor of the changes, clarifications or such other information as the case may be. This letter will instruct the contractor whether or not to proceed with the work and will request an itemized quotation for any applicable change to the contract scope of work.

The contractor's quotation will be analyzed for correctness. After the review and analysis of the quotation by the Facilities Project Manager, it will be incorporated into the appropriate change estimate. Upon City's approval, a contract change order will be issued. Prompt response and submission of the itemized quotation, together with detailed quantity breakdowns of the work and subcontractor and supplier backups, will expedite approval of all changes. The contractor must reply to the City's letter within seven (7) calendar days of its issuance. Failure by the contractor to timely respond to this letter will cause the City to apply a unilateral decision on the cost of the change. Incomplete quotations or insufficient supporting documentation will cause the quotations to be returned for revision and resubmission.

SPECIAL PROVISIONS

1. EXAMINATIONS AND INVESTIGATION BY CONTRACTOR

Prior to submitting a bid, the contractors shall examine all documents relating to this project and visit the job site to ascertain the nature of the work and the character of the job site. The contractors shall become familiar with the contractual requirements, project limitations, various aspects of the work, physical conditions and surroundings of the job site.

The contractors shall include in their bids a sum sufficient to cover the costs of doing the work under the existing site conditions and project requirements. By submitting a bid for the project, the contractor declares that he or she has thoroughly investigated the job site, examined all related project documents and is familiar and satisfied with the nature, character and condition of the project site, contractual requirements, project limitations and the various aspects of this project. The City will not consider any claims for compensation whatsoever on account of the contractors' failure to fully investigate and examine the project requirements and job site conditions as required above.

2. CONSTRUCTION SCHEDULE

The construction shall be completed within sixty (60) days from approval of the purchase order. The starting date to be approved by the City.

3. PUBLIC CONVENIENCES AND SAFETY

The contractor shall maintain sufficient safeguards against the occurrence of accidents, injuries or damage to any person or property. Barricades shall be placed around all work areas when work is not in progress as directed by the Facilities Project Manager or the Safety Manager.

4. SCOPE OF WORK

4.1 Variable Frequency Drive (VFD) Replacement

Remove the existing VFDs and door-mounted displays.

4.1.1 Summary

The two main air handlers serving the Library have VFDs for the supply fans and return fans. The four OEM VFDs are built into the Square D MCC located in the penthouse mechanical room adjacent to

the chiller. Parts are no longer available for these VFDs, and one of the VFDs has failed. This project will replace the old VFDs with new VFDs per Specification Section 15945.

Fan	Motor HP 460/3	MCC Section Width
AHU-1 Supply Fan	50	36"
AHU-1 Return Fan	25	16"
AHU-2 Supply Fan	60	36"
AHU-2 Return Fan	30	20"

4.1.2 Existing Conditions

The existing VFDs and bypasses are built into MCC cubical sections. All sections are 7' high by 21" deep. The widths are shown in the

table above. The sections have backboards that are only 8" deep, however. The bypass components and wiring are built up on the backboard. The circuit breaker and Square D VFD are also mounted to the backboard. The doors have the breaker switch handle, a "drive-off-bypass" selector with three indicator lights and a keypad for the drive itself. The doors also have louvered openings for the drive cooling fan air intake and exhaust.

The MCC bussing is located behind the 8" backboard. This bussing is immediately behind the backboard (not up against the back of the MCC).

4.1.3 Execution

Remove the existing VFDs and door-mounted displays. The breakers, bypass and drive-off-bypass selector shall remain and be reused. Install new VFD. Modify the backboard, bussing and bypass, as needed, to fit the new VFD inside the MCC section. Remote mount the VFD keypad panel to the MCC door. Provide cooling fans for the VFDs to efficiently and effectively draw air in and out of the sections. If the keypad and cooling fan openings cannot be adapted to the existing MCC section doors in an attractive and aesthetically pleasing manner, replace the MCC section doors with new doors. Bare sheet metal patches on the face of the door will not be accepted. Disconnect and reconnect the Johnson DDC control wiring, including start/stop, status, speed signal and feedback. Test and commission the VFD controls. Vendors shall visit the site and inspect the existing installation prior to submitting their bids.

Submit complete shop drawings for approval prior to construction. Due to the possible modifications to the MCC backboard, VFD bypass and MCC bussing, only preapproved vendors with expertise in this work may bid this work. Two preapproved vendors are listed below.

Square D Field Service (Fairfield)

(707) 447-9122

Dan Lake or Linda Rush

OR

Intec Solutions

(888) 664-6832

Chris

4.1.4 Reference Drawings

- Refer to Reference Drawing Sheet E0.1 for the existing building one-line diagram, including the MCC with the VFDs (or AFCs as they are called on the one-line).
- Refer to Detail 4/E0.2 for the detail and dimensions of the MCC section housing the existing VFDs.
- Refer to Detail 2/M1.4 for the approximate location of the AHU-1 and AHU-2 motor control center. Note that the actual location of the MCC is not along the wall, as shown in this view, but closer to the chiller.

4.1.5 VFD Installation Scheduling

Plan and execute this work so that only one air handler is down at a time. The downtime shall be during the week and limited to two (2) days per air handler. The scheduling of this work shall be as directed by the City maintenance staff and Fleet Services Manager.

4.1.6 Startup

An ABB factory authorized representative shall start the VFDs with a representative from the City. Provide a complete startup report to the City's Fleet Services Manager.

4.2 BUILDING PRESSURE CONTROLS

4.2.1 Summary

Presently, the building does not have building pressure controls. Currently, the air handler supply and return fans are given a proportional speed signal where the proportion is constant. Install the controls, set the outside air dampers and make changes to the control sequences to control building pressure.

4.2.2 Materials

Install a new building pressure point "BP." A single point will be used for both floors since the two floors are open to one another. Install a transducer to sense building pressure per Specification Section 15934. Mount the transducer in a temperature control panel and install 1/4" copper tubing to the building pressure sensing point. Install a blank cover labeled "BP." Install 1/4" copper tubing to the building exterior for reference. Terminate this tube with an accessory-sensing tube intake (with filter). New tubing shall be concealed or installed in wire mold if it cannot be concealed. See Reference Sheet M1.3 for the location of the BP sensing point.

4.2.3 Sequence Of Operation

The following sequence is intended to control the building to a constant positive pressure of 0.02".

For each air handler, create a virtual point for the ratio of the speed of the supply fan to the return fan. This ratio shall be adjusted based on building pressure. The ratio shall always be \leq to 1.0. The ratio shall be based on the frequency output of the VFDs. This frequency output shall be obtained from the network connection to the VFD. The output signal from the VFD is to be used rather than the DDC control speed signal so the building pressure controls will respond to the VFD being put in "hand" or bypass modes.

The initial value for the speed ratio shall be 1.0 (supply fans and return fan both running at same speed). With the fans operating at this ratio, set the outside air dampers on both air handlers. With the air handlers in RECIRCULATION mode, fully close the exhaust and OA dampers and fully open the return damper. In this mode, the building pressure should be negative due to the 4800 cfm of rest

room exhaust in the building. Mechanically adjust the position of the OA dampers only to achieve a building pressure of +0.02". Open the OA dampers on both air handlers equally. Mechanically open the dampers, and install physical stops so the dampers never close below the minimum needed to achieve 0.02". Note that in 100 percent ECONOMIZER mode, the EA and OA dampers shall be fully open, and the return damper shall be fully closed.

Use the building pressure signal to reset the speed ratios of both air handlers. If building pressure goes negative (drops below -0.01" continuously for one minute), reduce the speed ratio of both air handlers by 1 percent. Repeat for every minute the building pressure is negative. For example, with an initial ratio of 1.0 after five minutes of negative pressure, the return fans would be running at 95 percent of the speed of the supply fans. Conversely, if building pressure becomes too positive (exceeds +0.04" for one minute), increase the speed ratio by 1 percent to a maximum ratio of 1.0.

Trend building pressure and the speed ratio for a week. Submit this data to the City and design engineer. Make allowance for changing set-points as directed by the engineer.

4.3 CO₂ Controls

4.3.1 Summary

Install CO₂ sensors to control the outside air. Connect these controls to the existing Johnson Controls EMS system. New CO₂ sensors shall be installed per Specification Section 15934. Note that one outside reference and two indoor sensors (one for each air handler) are required.

4.3.2 Sequence Of Operation

The mixed air damper control sequence shall be modified to include CO₂ level control: A "Δ CO₂" level shall be calculated for each air handler. Δ CO₂ shall be: CO₂AHU– CO₂OA (for each air handler). In recirculation mode only, the outside air damper position shall be based on Δ CO₂ levels per the table below. In economizer modes, the outside air damper shall be unaffected by CO₂ levels.

CO ₂ LEVEL	CONTROL SEQUENCE CHANGES
• CO ₂ • 400 PPM	Close OA damper to minimum position
400 PPM < • CO ₂ < 700 PPM	Modulate OA dampers between minimum and 30 percent
• CO ₂ • 700 PPM	Open OA Damper to 30 percent

Trend the CO₂ levels and OA damper positions for a week while in recirculation mode. Submit this data to the engineer. Make allowance for changing set-points as directed by the engineer.

4.3.3 Sensor Locations

The CO₂ sensors for the two air handlers shall be mounted inside the return plenum of the air handlers. The OA reference shall be mounted on the mechanical penthouse wall between the two air handlers. (See Reference Drawing M1.4 for locations.)

TECHNICAL SPECIFICATIONS

SECTION 01100 – SUMMARY

PART 1. GENERAL

1.01 Design Engineer

Engineer: Salas O'Brien Engineers, Inc.; (408) 282-1600

1.02 Contract Description

- A. Contract Type: A single prime contract based on a stipulated price as described in Document 00500 – Agreement.

1.03 Description of Alterations Work

- A. Scope of demolition and removal work is shown on drawings and specified herein.
- B. Scope of alterations work is shown on drawings and specified herein.
- C. Renovate the following areas, complete including operational mechanical and electrical work:
 - 1. Air handling unit AHU-1 and AHU-2 carbon dioxide controls.
 - 2. Air handling unit AHU-1 and AHU-2 room pressure controls.
 - 3. Variable frequency drive replacements for AHU-1 and AHU-2 (four total).

1.04 Owner Occupancy

- A. Owner intends to continue to occupy portions of the existing building during the entire construction period.
- B. Cooperate with owner to minimize conflict and to facilitate owner's operations.
- C. Schedule the work to accommodate owner occupancy.

1.05 Contractor Use of Site and Premises

- A. Construction Operations: Limited to areas noted on drawings.
- B. Arrange use of site and premises to allow:
 - 1. Owner occupancy.
- C. Provide access to and from site as required by law and by owner.
- D. Emergency Building Exits During Construction: Keep all exits required by code open during construction period; provide temporary exit signs if exit routes are temporarily altered.
- E. Limit shutdown of utility services to four (4) hours at a time, arranged at least twenty-four (24) hours in advance with owner.

1.06 Work Sequence

- A. Coordinate construction schedule and operations with owner.

SECTION 01300 – ADMINISTRATIVE REQUIREMENTS

PART 1. GENERAL

1.01 Section Includes

- A. Preconstruction meeting.
- B. Progress meetings.
- C. Construction progress schedule.
- D. Submittals for review, information and project closeout.
- E. Submittal procedures.

PART 2. PRODUCTS – NOT USED

PART 3. EXECUTION

3.01 Preconstruction Meeting

- A. Owner will schedule a meeting after Notice of Award.
- B. Attendance Required
 - 1. Owner.
 - 2. Engineer.
 - 3. Contractor.
- C. Agenda
 - 1. Execution of Owner/Contractor Agreement.
 - 2. Submission of executed bonds and insurance certificates.
 - 3. Distribution of contract documents.
 - 4. Submission of list of subcontractors, list of products, schedule of values and progress schedule.
 - 5. Designation of personnel representing the parties to contract and engineer.
 - 6. Procedures and processing of field decisions, submittals, substitutions, applications for payments, proposal request, change orders and contract closeout procedures.
 - 7. Scheduling.
- D. Record minutes and distribute copies within two (2) days after meeting to participants with one copy to engineer, owner, participants and those affected by decisions made.

3.02 Progress Meetings

- A. Schedule and administer meetings throughout progress of the work at maximum monthly intervals.
- B. Attendance Required: Job superintendent, major subcontractors and suppliers, owner and engineer, as appropriate to agenda topics for each meeting.
- C. Agenda
 - 1. Review minutes of previous meetings.
 - 2. Review of work progress.
 - 3. Field observations, problems and decisions.
 - 4. Identification of problems which impede planned progress.
 - 5. Review of submittals schedule and status of submittals.
 - 6. Maintenance of progress schedule.
 - 7. Corrective measures to regain projected schedules.
 - 8. Planned progress during succeeding work period.
 - 9. Maintenance of quality and work standards.
 - 10. Effect of proposed changes on progress schedule and coordination.
 - 11. Other business relating to work.
- D. Record minutes and distribute copies within two (2) days after meeting to participants with two copies to engineer, owner, participants and those affected by decisions made.

3.03 Construction Progress Schedule

- A. Within ten (10) days after date of the Agreement, submit preliminary schedule defining planned operations for the first sixty (60) days of work with a general outline for remainder of work.

- B. If preliminary schedule requires revision after review, submit revised schedule within ten (10) days.
- C. Within twenty (20) days after review of preliminary schedule, submit draft of proposed complete schedule for review.
 - 1. Include written certification that major contractors have reviewed and accepted proposed schedule.
- D. Within ten (10) days after joint review, submit complete schedule.
- E. Submit updated schedule with each application for payment.

3.04 Submittals for Review

- A. When the following are specified in individual sections, submit them for review:
 - 1. Product data.
 - 2. Shop drawings.
 - 3. Samples for selection.
 - 4. Samples for verification.
- B. Submit to engineer for review for the limited purpose of checking for conformance with information given and the design concept expressed in the contract documents.
- C. Samples will be reviewed only for aesthetic, color or finish selection.
- D. After review, provide copies and distribute in accordance with SUBMITTAL PROCEDURES article below and for record documents purposes described in Section 01780 – Closeout Submittals.

3.05 Submittals for Information

- A. When the following are specified in individual sections, submit them for information:
 - 1. Design data.
 - 2. Certificates.
 - 3. Test reports.
 - 4. Inspection reports.
 - 5. Manufacturer's instructions.
 - 6. Manufacturer's field reports.
 - 7. Other types indicated.
- B. Submit for engineer's knowledge as contract administrator or for owner. No action will be taken.

3.06 Submittals for Project Closeout

- A. When the following are specified in individual sections, submit them at project closeout:
 - 1. Project record documents.
 - 2. Operation and maintenance data.
 - 3. Warranties.
 - 4. Bonds.
 - 5. Other types as indicated.

3.07 Number of Copies Of Submittals

- A. Documents for Review
 - 1. Small Size Sheets (not larger than 8-1/2" by 11"): Submit the number of copies which the contractor requires, plus two copies which will be retained by the engineer.
- B. Documents for Information: Submit two copies.
- C. Samples: Submit the number specified in individual specification sections, one of which will be retained by engineer.
 - 1. After review, produce duplicates.
 - 2. Retained samples will not be returned to contractor unless specifically so stated.

3.08 Submittal Procedures

- A. Transmit each submittal with approved form.
- B. Sequentially number the transmittal form. Revised submittals shall be indicated with original number and a sequential alphabetic suffix.
- C. Identify project, contractor, subcontractor or supplier; pertinent drawing and detail number; and specification section number, as appropriate, on each copy.
- D. Apply contractor's stamp, signed or initialed, certifying that review, approval, verification of products required, field dimensions, adjacent construction work, and coordination of information is in accordance with the requirements of the work and contract documents.
- E. Deliver submittals to engineer at business address.
- F. Schedule submittals to expedite the project, and coordinate submission of related items.
- G. For each submittal for review, allow fifteen (15) days, excluding delivery time to and from the contractor.

- H. Identify variations from contract documents and product or system limitations which may be detrimental to successful performance of the completed work.
- I. Provide space for contractor and engineer review stamps.
- J. When revised for resubmission, identify all changes made since previous submission.
- K. Distribute copies of reviewed submittals, as appropriate. Instruct parties to promptly report any inability to comply with requirements.
- L. Submittals not requested will not be recognized or processed.
- M. Engineer's review will result in the return of the submittal with one of the following marks:
 - 1. "Reviewed" – Materials may be provided as described in the submittal.
 - 2. "See Attached Notes" – Materials may be provided as described in the submittal, in accordance with comments or notes or additional requirements noted by the reviewer.
 - 3. "Not Acceptable" – Materials are unacceptable and shall not be provided.
 - 4. "Revise and Resubmit" – Requires that the submittal be modified according to requirements noted and resubmitted.
- N. Materials or equipment shall not be delivered to the job site without first obtaining a submittal which has the "Reviewed" or "See Attached Notes" stamp mark.

SECTION 15934 – FACILITY MANAGEMENT SYSTEM

PART 1. GENERAL

1.01 System Summary

- A. Furnish a Johnson Controls Metasys-based Direct Digital Control System (DDCS) in accordance with this specification section (no substitutions). All new controls equipment, as part of this project, shall be connected to the

Metasys system. The EMS system shall be manufactured by Johnson Controls.

1.02 Quality Assurance

A. General

1. The Facility Management System (FMS) herein specified shall be fully integrated and installed as a complete package. No substitution. The system shall include all wiring, piping, installation supervision, calibration, adjustments and checkout necessary for a complete and fully operational system.

B. Governing Code Compliance

1. The FMS contractor shall comply with all current governing codes, ordinances and regulations, including UL, NFPA, the local Building Code, NEC, and so forth.

1.03 Submittals

A. Shop Drawings, Product Data and Samples

1. The FMS contractor shall submit within sixty (60) days after award installation drawings and control strategies for review.
2. Each submittal shall have a cover sheet with the following information provided: submittal ID number; date; project name, address and title; FMS contractor name, address and phone number; FMS contractor project manager, quality control manager and project engineer names and phone numbers.
3. Each submittal shall include the following information:
 - a. FMS riser diagram showing all DDC controllers, operator workstations, network repeaters and network wiring.
 - b. One-line schematics and system flow diagrams showing the location of all control devices.
 - c. Points list for each DDC controller, including: Tag, Point Type, System Name, Object Name, Expanded ID, Display Units, Controller Type, Address, Cable Destination, Module Type,

Terminal ID, Panel, Slot Number, Reference Drawing and Cable Number.

- d. Vendor's own written description for each sequence of operations to include the following:
 - (1) Sequences shall reference input/output and software parameters by name and description.
 - (2) The sequences of operations provided in the submittal by the FMS contractor shall represent the detailed analysis needed to create actual programming code from the design documents.
 - (3) Points shall be referenced by name, including all software points such as programmable setpoints, range limits, time delays, etc.
 - (4) The sequence of operations shall cover normal operation and operation under the various alarm conditions applicable to that system.

1.04 Warranty

A. Material

- 1. The control system shall be free from defects in material and workmanship under normal use and service. If within thirty-six (36) months from the date of completion any of the equipment herein described is defective in operation, workmanship or materials, it will be replaced, repaired or adjusted at the option of the FMS contractor free of charge.

B. Installation

- 1. The control system shall be free from defects in installation workmanship for a period of one year from acceptance. The FMS contractor shall, free of charge, correct any defects in workmanship within one week of notification, in writing, by the owner.

PART 2. PRODUCTS

2.01 Network Controllers

A. Network Controller

1. Utilize existing NCM 350 supervisor controllers to map new points into existing system.

2.02 Input Devices

A. Room Carbon Dioxide Sensors

1. Nondispersive infrared (NDIR) diffusion sampling analyzer designed for measuring environmental carbon dioxide concentration in ventilation systems in working spaces. Range 0-2000 PPM, 24 VAC, 0-10 VDC output, ± 75 PPM accuracy, repeatability of ± 20 PPM. Platinum RTD sensor. Veris CWE S B for room mounting.

B. Outside Air Carbon Dioxide Sensor

1. Nondispersive infrared (NDIR) diffusion sampling analyzer designed for measuring environmental carbon dioxide concentration in ventilation systems in working spaces. Range 0-2000 PPM, 24 VAC, 0-10 VDC output, ± 40 PPM accuracy, repeatability of ± 20 PPM. Outside air enclosure. TelAire 8002-K with 1551 cover.

C. Pressure Sensors

1. Digital room differential pressure transmitter with LED readout with microprocessor profiled sensor. Capacitive sensing element for stable linear output. 24 VAC or DC, 0-10 VDC output, 0.1" bidirectional pressure range, LCD display, 1 percent full scale accuracy combined linearity and hysteresis. Veris PX P L N 01 S

PART 3. EXECUTION

3.01. Installation Practices

A. HVAC Control System Wiring

1. All conduit, wiring, accessories and wiring connections required for the installation of the Facility Management System, as herein specified,

shall be provided by the FMS contractor unless specifically shown on the electrical drawings under Division 16, Electrical. All wiring shall comply with the requirements of applicable portions of Division 16 and all local and national electric codes unless specified otherwise in this section.

2. All system input wiring shall be twisted shielded pair, minimum 18-gauge wire. All system analog output wiring shall be twisted shielded pair/3-wire, as required, minimum 18-gauge wire. Preconfigured cables between terminal unit controllers and thermostats are acceptable, minimum 24 gauge.
 3. All internal panel device wiring for binary outputs and pilot relay shall be minimum 16-gauge wire.
 4. All Class 2 (24 VAC or less) wiring shall be installed in conduit unless otherwise specified.
 - a. Class 2 wiring not installed in conduit shall be supported every 5' from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements. Exposed wiring shall only be allowed in concealed accessible locations. Where wiring cannot be concealed behind walls, utilize wire mold.
 5. Low-voltage control wiring and 24 VAC can be run in the same conduit. Power wiring 120 VAC and greater must be in a separate conduit.
- B. Primary and secondary communications network cabling.
1. Cable shall be of type recommend by the DDC system manufacturer.

3.02 Training

- A. The controls contractor shall provide the following training services:
1. One day of on-site orientation by a field engineer who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the control system software layout and naming

conventions, and a walkthrough of the facility to identify panel and device locations.

3.03 Commissioning

- A. Commissioning the Facility Management System is a mandatory documented performance requirement of the selected FMS contractor for all control systems detailed in this specification and sequence of operations. Commissioning shall include verification of proper installation practices by the FMS contractor and subcontractors under the FMS contractor, point verification and calibration, system/sequence of operation verification with respect to specified operation, and network/workstation verification. Documentation shall be presented upon completion of each commissioning step and final completion to ensure proper operation of the Facility Management System.

SECTION 15945 – VARIABLE FREQUENCY DRIVES-550

PART 1. GENERAL

1.01 Section Includes

- A. Variable frequency drives.

1.02 References

- A. Institute of Electrical and Electronic Engineers (IEEE).
- B. Standard 519-1992, IEEE Guide for Harmonic Content and Control.
- C. Underwriters Laboratories.
- D. UL508C.
- E. National Electrical Manufacturers Association (NEMA).
- F. ICS 7.0, AC Variable Speed Drives.
- G. IEC 16800 Parts 1 and 2.
- H. NEMA ICS 7.1 – Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems; 1995.

- I. NETA STD ATS— Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (International Electrical Testing Association); 1995.
- J. IEEE 519.

1.03 System Description

- A. This specification is to cover a complete variable frequency motor drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use on a standard NEMA Design B induction motor. The drive shall be manufactured by ABB, be designed specifically for variable torque applications, and be designated "ACH 550". It is required that the drive manufacturer has an existing:
 - 1. Sales representative exclusively for HVAC products with expertise in HVAC systems and controls.
 - 2. An independent service organization.
- B. The drive and all necessary controls, as herein specified, shall be supplied by the drive manufacturer. The manufacturer shall have been engaged in the production of this type of equipment for a minimum of ten (10) years.

1.04 Submittals

- A. See Division 1, Administrative Requirements, for submittal procedures.
- B. Product Data: Provide catalog sheets on variable frequency drive (controller) showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.
- C. Shop Drawings: Indicate front and side views of enclosures with overall dimensions and weights shown, conduit entrance locations and requirements, and nameplate legends.
- D. Submittals shall include the following information:
 - 1. Outline dimensions.
 - 2. Weight.

- E. Compliance to IEEE 519—harmonic analysis for particular job site, including total harmonic voltage distortion and total harmonic current distortion.
 - 1. The VFD manufacture shall provide calculations, specific to this installation, showing total harmonic voltage distortion is less than 5 percent. Input line filters shall be sized and provided, as required by the VFD manufacturer, to ensure compliance with IEEE standard 519 (latest version), Guide for Harmonic Control and Reactive Compensation for Static Power Converters. The acceptance of this calculation must be completed prior to VFD installation.
 - 2. Prior to installation, the VFD manufacturer shall provide the estimated total harmonic distortion (THD) caused by the VFDs. The results shall be based on a computer-aided circuit simulation of the total actual system with information obtained from the power provider and the user.
 - 3. All drives shall include a minimum of 5 percent impedance reactors. If the voltage THD exceeds 5 percent, the VFD manufacturer is to recommend the additional equipment required to reduce the voltage THD to an acceptable level.
- F. Test Reports: Indicate field test and inspection procedures and test results.
- G. Manufacturer's Field Reports: Indicate startup inspection findings.

1.05 Quality Assurance

- A. Testing
 - 1. All printed circuit boards shall be completely tested and burned in before being assembled into the completed VFD. The VFD shall then be subjected to a computerized systems test (cold), burn-in and computerized systems test (hot). The burn-in shall be at 104° F (40° C), at full rated load.
 - 2. All testing and manufacturing procedures shall be ISO 9001 certified.
- B. Failure Analysis
 - 1. VFD manufacturer shall have an analysis laboratory to evaluate the failure of any component. The failure analysis lab shall allow the

manufacturer to perform complete electrical testing, x-ray of components, and decap or delaminate of components, and analyze failures within the component.

C. Qualifications

1. VFDs and options shall be UL listed as a complete assembly. The base VFD shall be UL listed for 100 KAIC without the need for input fuses.
2. VFDs and options shall be UL listed as a complete assembly.
3. VFDs and options shall be CE labeled as a component.

D. Conform to requirements of NFPA 70.

E. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum five (5) years documented experience and with service facilities within 100 miles of project.

1.06 Delivery, Storage and Handling

- A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris and traffic.
- B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to components, enclosure and finish.

1.07 Maintenance Service

- A. Provide service and maintenance of controller for one year from date of substantial completion.

1.08 Extra Materials

- A. Documentation: Furnish three sets of operating manuals to the owner.
- B. Fuses: Furnish two sets of each type and rating of fuses installed.

1.09 Warranty

- A. Warranty shall be twenty-four (24) months from the date of certified startup, not to exceed thirty (30) months) from the date of manufacturer. The warranty shall include all parts, labor, travel time and expenses.

PART 2. PRODUCTS

2.01 Variable Frequency Drives

- A. The VFDs shall be solid state, with a pulse width modulated (PWM) output. The VFD package, as specified herein, shall be enclosed in a NEMA 1 enclosure, completely assembled and tested by the manufacturer. The VFD shall employ a full wave rectifier (to prevent input line notching), integral line reactor(s), capacitors and insulated gate bipolar transistors (IGBTs) as the output switching device. The drive efficiency shall be 97 percent or better at full speed and full load. Fundamental power factor shall be 0.98 at all speeds and loads.
- B. Specifications for the ACH 550
 - 1. Input 460/480 VAC +/- 10 percent, 3-phase, 48-63 Hz or input 208/220/230/240 VAC +/- 10 percent, 3-phase, 48-63 Hz. Undervoltage trip @ rated input -35 percent. Overvoltage trip @ rated input +30 percent.
 - 2. Interrupt rating 65 kAIC, suitable for use on a circuit capable of delivering not more than 65,000 RMS symmetrical amps, 480V maximum.
 - 3. Output frequency 0 to 250 Hz. Operation above 60 Hz shall require programming changes to prevent inadvertent high-speed operation.
 - 4. Environmental operating conditions: 0 to 40° C, 0 to 3,300' above sea level, less than 95 percent humidity, noncondensing.
 - 5. The VFD package, as specified herein, shall be enclosed in a UL-listed Type 12 enclosure, completely assembled and tested by the manufacturer in an ISO9001 facility.

C. All VFDs shall have the following standard features:

1. All VFDs shall have the same customer interface, including digital display and keypad, regardless of horsepower rating. The keypad is to be used for local control, for setting all parameters and for stepping through the displays and menus. The keypad shall be removable, be capable of remote mounting, and have its own nonvolatile memory. The keypad shall allow for uploading and downloading of parameter settings as an aid for startup of multiple VFDs.
2. The keypad shall include hand-off-auto membrane selections. When in "Hand," the VFD will be started and the speed will be controlled from the up/down arrows. When in "Off," the VFD will be stopped. When in "Auto," the VFD will start via an external contact closure and the VFD speed will be controlled via an external speed reference. The drive shall incorporate "bumpless transfer" of speed reference when switching between "Auto" and "Hand" modes. There shall be fault reset and "Help" buttons on the keypad. The "Help" button shall include "on-line" assistance for programming and troubleshooting.
3. The VFDs shall utilize preprogrammed application macros specifically designed to facilitate startup. The application macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time. The AFD shall have two user macros to allow the end-user to create and save custom settings.
4. The VFD shall have cooling fans that are designed for easy replacement. The fans shall be designed for replacement without requiring the removal of the VFD from the wall or removal of circuit boards. The VFD cooling fans shall operate only when required. To extend the fan and bearing operating life, operating temperature will be monitored and used to cycle the fans on and off as required.
5. There shall be a built-in time clock in the VFD keypad. The clock shall have a battery backup with a ten (10) year minimum life span. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault. If the battery fails, the VFD shall automatically revert to hours of operation since initial power-up. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter sets and output relays. The VFD shall have a digital input that allows an override to the time clock (when in the off mode) for a programmable timeframe. There shall be four

- (4) separate, independent timer functions that have both weekday and weekend settings.
6. The VFD shall have the ability to automatically restart after an overcurrent, overvoltage, undervoltage or loss of input signal protective trip. The number of restart attempts, trial time and time between reset attempts shall be programmable.
 7. The VFD shall be capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to setpoint without safety tripping or component damage (flying start). The VFD shall also be capable of DC injection braking at start to stop a reverse spinning motor prior to ramp.
 8. The VFD shall be equipped with an automatic extended control power ride-through circuit, which will utilize the inertia of the load to keep the drive powered. Typical control power ride-through for a fan load shall be two (2) seconds minimum.
 9. If the input reference (4-20mA or 2-10V) is lost, the VFD shall give the user the option of either: (1) stopping and displaying a fault; (2) running at a programmable preset speed; (3) hold the VFD speed based on the last good reference received; or (4) cause a warning to be issued, as selected by the user. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communication bus.
 10. The customer terminal strip shall be isolated from the line and ground.
 11. The drive shall employ current limit circuits to provide trip free operation:
 - a. The slow current regulation limit circuit shall be variable to 150 percent (minimum) of the VFD's normal duty current rating. This adjustment shall be made via the keypad and shall be displayed in actual amps, not as percent of full load.
 - b. The current switch-off limit shall be fixed at 350 percent (minimum, instantaneous) of the VFD's normal duty current rating.
 12. The overload rating of the drive shall be 110 percent of its normal duty current rating for one (1) minute in every ten (10) minutes, 130 percent

overload for two (2) seconds. The minimum FLA rating shall meet or exceed the values in the NEC/UL Table 430-150 for 4-pole motors.

13. The VFD shall have an integral 5 percent impedance line reactors to reduce the harmonics to the power line and to add protection from AC line transients. The 5 percent impedance may be from dual (positive and negative DC bus) reactors or 5 percent AC line reactors. VFDs with only one DC reactor shall add AC line reactors.
14. The VFD shall include a coordinated AC transient protection system consisting of 4-120 joule-rated MOVs (phase-to-phase and phase-to-ground), a capacitor clamp and 5 percent impedance reactors.
15. The VFD shall be capable of sensing a loss of load (broken belt/no water in pump) and signal the loss of load condition. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. Relay outputs shall include programmable time delays that will allow for drive acceleration from zero speed without signaling a false underload condition.
16. The VFD shall have programmable "Sleep" and "Wake Up" functions to allow the drive to be started and stopped from the level of a process feedback or follower signal.

D. All VFDs to have the following adjustments:

1. Three (3) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed.
2. Two (2) PID setpoint controllers shall be standard in the drive, allowing pressure or flow signals to be connected to the VFD, using the microprocessor in the VFD for the closed loop control. The VFD shall have 250 mA of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. The auxiliary power supply shall have overload and over-current protection. The PID setpoint shall be variable from the VFD keypad, analog inputs, or over the communications bus. There shall be two parameter sets for the first PID that allow the sets to be switched via a digital input, serial communications or from the keypad for night setback, summer/winter setpoints, etc. There shall be an independent, second PID loop that can utilize the second analog input and modulate one of the analog outputs to maintain setpoint of an independent process (i.e., valves,

dampers, etc.). All setpoints, process variables, etc., to be accessible from the serial communication network. The setpoints shall be set in Engineering units and not require a percentage of the transducer input.

3. Two (2) programmable analog inputs shall accept a current or voltage signal for speed reference or for reference and actual (feedback) signals for PID controller. Analog inputs shall include a filter, programmable from 0.01 to 10 seconds, to remove any oscillation in the input signal. The minimum and maximum values (gain and offset) shall be variable within the range of 0-20 ma and 0-10 Volts. Additionally, the reference must be able to be scaled so that maximum reference can represent a frequency less than 60 Hz without lowering the drive maximum frequency below 60 Hz. Process variables shall be modifiable by math functions such as multiplication and division between the two signals (fan tracking) and high/low select, as well as inverted follower. Relays shall be capable of programmable on and off delay times.
4. Two (2) programmable analog outputs (0-20 ma or 4-20 ma). The outputs may be programmed to output proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power (kW), DC Bus voltage, Active Reference, and other data.
5. Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices, typically programmed as follows:
 - a. There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, input contact closure, time-clock control or serial communications), the VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end switch) shall close. The closed end switch is wired to an VFD digital input and allows VFD motor operation. Two (2) separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop, and the damper shall be commanded to close. The keypad shall display "start enable 1 (or 2) missing." The safety status shall also be transmitted over the serial communications bus. All digital inputs shall be programmable to initiate upon an application or removal of 24 VDC.
6. Three (3) programmable digital Form C relay outputs. The relays shall include programmable on and off delay times and adjustable

hysteresis. Default settings shall be for run, not faulted (fail safe) and run permissive. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 A at 250 VAC; maximum voltage 300 VDC and 250 VAC; continuous current rating 2 amps RMS. Outputs shall be true Form C-type contacts; open collector outputs are not acceptable.

7. Seven (7) programmable preset speeds.
 8. Two (2) independently adjustable accel and decel ramps with 1-1,800 seconds adjustable time ramps.
 9. The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and audible motor noise.
 10. The VFD shall include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows the highest carrier frequency without derating the VFD or operating at high carrier frequency only at low speeds.
 11. The VFD shall include password protection against parameter changes.
- E. The following operating information displays shall be standard on the VFD digital display. All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of two operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words. (Alpha-numeric codes are not acceptable.)
1. Output Frequency
 2. Motor Speed (RPM, percent or engineering units)
 3. Motor Current
 4. Calculated Motor Torque
 5. Calculated Motor Power (kW)
 6. DC Bus Voltage

7. Output Voltage
8. Analog Input Values
9. Analog Output Value
10. Keypad Reference Values
11. Elapsed Time Meter (resettable)
12. kWh meter (resettable)
13. mWh meter
14. Digital input status
15. Digital output status
16. Ammeter
17. Run / Stop selection for existing LED's

- F. The VFD shall have the following protection circuits. In the case of a protective trip, the drive shall stop and announce the fault condition in complete words. (Alphanumeric codes are not acceptable.)
1. Overcurrent trip 350 percent instantaneous (170 percent RMS) of the VFD's variable torque current rating.
 2. Overvoltage trip 130 percent of the VFD's rated voltage.
 3. Undervoltage trip 65 percent of the VFD's rated voltage.
 4. Overtemperature +90° C, Heatsink temperature.
 5. Ground fault either running or at start.
 6. Adaptable electronic motor overload (I 2 t). The electronic motor overload protection shall protect the motor based on speed, load curve and external fan parameter. Circuits, which are not speed dependant, are unacceptable. The electronic motor overload protection shall be UL listed for this function.

7. DC bus over-voltage protection
 8. Able to withstand line to line short circuits without component failure
- G. Display for Protective Functions:
1. Under-voltage
 2. Over-voltage
 3. Over-amperage
 4. Over-Temp
 5. Overload
 6. Over-frequency
- H. Speed command input shall be via:
1. Keypad.
 2. Two analog inputs, each capable of accepting a 0-20 mA, 4-20 mA, 0-10V, 2-10V signal.
 3. Floating point input shall accept a three-wire input from a Dwyer Photohelic (or equivalent type) instrument.
 4. Serial communications.
- I. Serial Communications
1. The AFD shall have an RS-485 port as standard. The standard protocols shall be Modbus, Johnson Controls N2 bus and Siemens Building Technologies FLN. Optional protocols for LonWorks, BACnet, Profibus, Ethernet and DeviceNet shall be available. Each individual drive shall have the protocol in the base AFD. The use of third-party gateways and multiplexers is not acceptable. All protocols shall be "certified" by the governing authority. Use of noncertified protocols is not allowed.
 2. Serial communication capabilities shall include, but not be limited to, run-stop control, speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, accel/decel time adjustments, and lock and unlock the keypad. The drive shall have the capability of allowing the DDC to monitor feedback such as process variable feedback, output speed/frequency, current (in amps), percent

torque, power (kW), kilowatt hours (resettable), operating hours (resettable) and drive temperature. The DDC shall also be capable of monitoring the AFD relay output status, digital input status, and all analog input and analog output values. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote VFD fault reset shall be possible. The following additional status indications and settings shall be transmitted over the serial communications bus – keypad 'Hand' or 'Auto' selected, bypass selected, the ability to change the PID setpoint, and the ability to force the unit to bypass (if bypass is specified). The DDC system shall also be able to monitor if the motor is running in the AFD mode or bypass mode (if bypass is specified) over serial communications. A minimum of fifteen (15) field parameters shall be capable of being monitored.

3. The AFD shall allow the DDC to control the drive's digital and analog outputs via the serial interface. This control shall be independent of any AFD function. For example, the analog outputs may be used for modulating chilled water valves or cooling tower bypass valves. The drive's digital (relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. In addition, all of the drive's digital and analog inputs shall be capable of being monitored by the DDC system.
4. The VFD shall include an independent PID loop for customer use. The independent PID loop may be used for cooling tower bypass valve control, chilled water valve control, etc. Both the VFD control PID loop and the independent PID loop shall continue functioning even if the serial communications connection is lost. The VFD shall keep the last good set-point command and last good DO and AO commands in memory in the event the serial communications connection is lost.

2.02 Optional Features

- A. All optional features shall be UL listed by the drive manufacturer as a complete assembly and carry a UL 508 label.
- B. A complete factory wired and tested bypass system consisting of an input contactor, output contactor and bypass contactor. Overload protection shall be provided in both drive and bypass modes. Provide bypasses as scheduled on drawings.
- C. Microprocessor-Based Bypass Controller – Manual or automatic (selectable) transfer to line power via contactors. A keypad to control the bypass

controller is to be mounted on the enclosure door. The bypass keypad shall include a one-line diagram and status LEDs to indicate the mode of operation, drive and bypass status, and ready and enable conditions. When in the "Drive" mode, the bypass contactor is open and the drive output contactor is closed. In the "Bypass" position, the drive output contactor is open and the bypass contactor is closed via start/stop command. Start/stop via customer-supplied maintained contact shall be 24V or 115V compatible and shall function in both the "Drive" and "Bypass" modes. The voltage tolerance of the bypass power supply shall be +30/-35 percent to eliminate the problem of contactor coil burnout. The design shall include single-phase protection in both the VFD and bypass modes.

- D. Customer Interlock Terminal Strip – Provide a separate terminal strip for connection of freeze, fire, smoke contacts and external start command. All external safety interlocks shall remain fully functional whether the system is in Hand, Auto, Drive or Bypass modes.
- E. Automatic/manual bypass operation shall be selectable in the standard microprocessor-based bypass design.
- F. Door/cover interlocked disconnect switch which will disconnect all input power from the drive, bypass and all internally mounted options. The disconnect handle shall be through the door and be padlockable in the "Off" position.
- G. Fast-acting semiconductor fuses exclusive to the VFD fast-acting semiconductor fuses, allow the VFD to disconnect from the line prior to clearing upstream branch circuit protection, maintaining bypass capability. Bypass designs which have no such fuses or that incorporate fuses common to both the VFD and the bypass will not be accepted. In such designs, a fuse clearing failure would render the bypass unusable.
- H. Class 20 or Class 30 (selectable) electronic motor overload protection shall be included in the microprocessor bypass to protect the motor in bypass mode.
- I. Integral Input Reactors – Equivalent 5 percent impedance. Note that the standard VFD includes 3 percent line reactor(s).
- J. LonWorks Option – The optional LonWorks board allows for 78 kBit/s free topology communications to LonWorks networks.

PART 3. EXECUTION

3.01 General

- A. Installation shall be the responsibility of the mechanical contractor. The contractor shall install the drive in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.
- B. Power wiring shall be completed by the electrical contractor. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

3.02 Startup

- A. Certified factory startup shall be provided for each drive by a factory-authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner and a copy kept on file at the manufacturer.
- B. Include a certified field measurement verifying compliance.

3.03 Product Support

- A. Factory trained application engineering and service personnel that are thoroughly familiar with the ACH 550 drive products offered shall be locally available at both the specifying and installation locations.

3.04 Examination

- A. Verify that surface is suitable for controller installation.
- B. Do not install controller until building environment can be maintained within the service conditions required by the manufacturer.

3.05 Installation

- A. Install in accordance with NEMA ICS 7.1 and manufacturer's instructions.
- B. Tighten accessible connections and mechanical fasteners after placing controller.
- C. Select and install overload heater elements in motor controllers to match installed motor characteristics.

- D. Provide engraved plastic nameplates; refer to Section 16050 for product requirements and location.
- E. Neatly type label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating. Place in clear plastic holder.
- F. Reinstall start/stop, status and VFD input/output EMS connections to the new VFD.

3.06 Field Quality Control

- A. Perform field inspection and testing in accordance with Section 01450.
- B. Inspect and test in accordance with NETA STD ATS, except Section 4.
- C. Perform inspections and tests listed in NETA STD ATS, Section 7.17.

3.07 Adjusting

- A. Make final adjustments to installed controller to assure proper operation of load system. Obtain performance requirements from installer of driven loads.

3.08 Demonstration

- A. Demonstrate operation of controllers in automatic and manual modes.

SECTION 16010 – ELECTRICAL GENERAL PROVISIONS

PART 1. GENERAL

1.01 Section Includes

- A. Furnish all labor, materials, apparatus, tools, equipment, transportation, temporary construction and special or occasional services, as required, to make a complete working electrical installation, as shown on the drawings or described in these specifications.

1.02 Related Sections

- A. Perform the following work in accordance with appropriate sections of the specifications cited, where and as necessary, to furnish a complete working electrical installation.
 - 1. Miscellaneous Metal Work: Include fittings, brackets, supports, welding and pipe, as required, for raceway and disconnect switch support.
 - 2. Painting: Include surface preparation, priming and finish coating, as required, for electrical cabinets, exposed conduit, pull and junction boxes where specified. Refer to Division 9, Finishes.

1.03 References

- A. Reference to codes, standards, specifications and recommendations of technical societies, trade organizations and governmental agencies shall mean the latest edition of such publications adopted and published prior to submittal of the bid proposed. Such codes or standards shall be considered a part of this specification as though fully repeated herein.
- B. When codes, standards, regulations, etc., allow work of lesser quality or extent than is specified under this division, nothing in said codes shall be construed or inferred as reducing the quality, requirements or extent of the drawings and specifications.
- C. California Administrative Code (CAC) Title 24, Part 3, Basic Electrical Requirements, State Building Standards Electrical Code
- D. National Fire Protection Association (NFPA).
- E. Equipment and materials specified under this division shall conform to the following standards where applicable:
 - 1. UL – Underwriters Laboratories
 - 2. ASTM – American Society for Testing Materials
 - 3. CMB – Certified Ballast Manufacturers
 - 4. IPCEA – Insulated Power Cable Engineer Association

5. NEMA – National Electrical Manufacturers Association
 6. ANSI – American National Standards Institute
 7. ETL – Electrical Testing Laboratories
- F. All base material shall be ASTM and/or ANSI standards.
- G. All electrical apparatus furnished under this section shall conform to National Electrical Manufacturers Association (NEMA) standards and the NEC, and bear the Underwriters Laboratories (UL) label where such label is applicable.

1.04 Submittals

- A. See Section 01300, Administrative Requirements, for submittal procedures.
- B. Where items are noted as "or equal," a product of equal design, construction and performance will be considered. Contractor must submit all pertinent test data, catalog cuts and product information required to substantiate that the product is, in fact, equal. Refer to Division 1, General Requirement, for additional requirements. Only one substitution will be considered for each product specified.
- C. Submittals shall consist of detailed shop drawings, specifications, "catalog cuts" and data sheets containing physical and dimensioned information, performance data, electrical characteristics, material used in fabrication and material finish, and shall clearly indicate those optional accessories which are included and those which are excluded. Furnish one reproducible and 4four (4) prints of each shop drawing.

1.05 Cutting, Painting and Patching

- A. Structural members shall, in no case, be drilled, bored or notched in such a manner that will impair their structural value. Cutting of holes, if required, shall be done with core drill and only with the approval of the architect.
- B. Cutting and digging shall be under the direct supervision of the General Contractor. Include as necessary for the work in this section.
- C. The contractor shall be responsible for returning any surface from which he has removed equipment or devices to the condition and finish of the adjacent surfaces.

1.06 Supervision

- A. Contractor shall personally, or through an authorized and competent representative, constantly supervise the work from beginning to completion and, within reason, keep the same workmen and foreman on the project throughout the project duration.

1.07 Protection

- A. Keep conduits, junction boxes, outlet boxes, and other openings closed to prevent entry of foreign matter – cover fixtures, equipment and apparatus, and protect against dirt, paint, water, chemical or mechanical damage before and during construction period. Restore to original condition any fixture, apparatus or equipment damaged prior to final acceptance, including restoration of damaged shop coats of paint, before final acceptance. Protect bright finished surfaces and similar items until in service. No rust or damage will be permitted.

1.08 Examination of Site

- A. The contractor shall visit the site and determine the locale, working conditions, conflicting utilities and conditions in which the electrical work will take place. No allowances will be made subsequently for any costs which may be incurred because of any error or omission due to failure to examine the site and to notify the engineer of any discrepancies between drawings and specifications and actual site conditions. Schedule visits at least one (1) week in advance with owner's maintenance staff.

1.09 Environmental Requirements

- A. After other work such as sanding, painting, etc., has been completed, clean lighting fixtures, panelboards, switchboards and other electrical equipment to remove dust, dirt, grease or other marks, and leave work in clean condition.

1.10 Voltage Check

- A. At completion of job, check voltage at several points of utilization on the system which has been installed under this contract. During test, energize all loads installed. Measure 3-phase voltages and note percentage differences. Submit report to engineer. Include copy in O&M Manual.

1.11 Tests

- A. Perform tests as specified to prove installation is in accordance with contract requirements. Perform tests in the presence of the engineer and furnish test equipment, facilities and technical personnel required to perform tests. Tests shall be conducted during the construction period and at completion to determine conformity with applicable codes and with these specifications. Tests, in addition to specific system test described elsewhere, shall include:
 - 1. Insulation Resistance: All 600-volt insulation shall be tested at 2,500 volts DC for one (1) minute on all feeder and branch circuit conductors, including the neutral, and make a typed record of all readings to be included in the maintenance instructions. The direct current amperes shall be recorded at start and at one (1) minute. The value shall be declining and not more than one (1) microampere.
 - 2. Circuit Continuity: Test all feeder and branch circuits for continuity. Test all neutrals for improper ground.
- B. Equipment Operations: Test motors for correct operation and rotation.
- C. Product Failure: Any products which fail during the tests or are ruled unsatisfactory by the engineer shall be replaced, repaired or corrected as prescribed by the engineer at the expense of the contractor. Tests shall be performed after repairs, replacements or corrections until satisfactory performance is demonstrated.
- D. Miscellaneous: Include all test results in the maintenance manual. Cost, if any, for all tests shall be paid by the contractor.

1.12 Drawings

- A. Layout: General layout shown on the drawing shall be followed except where other work may conflict with the drawings.
- B. Accuracy
 - 1. Drawings for the work under this section are diagrammatic.
 - 2. Contractor shall verify lines, levels and dimensions shown on the drawings and shall be responsible for the accuracy of the setting out of work and for its strict conformance with existing conditions at the site.

3. Contractor shall ensure reconnection of existing equipment and circuits affected by contract demolition whether or not reconnection is specifically shown on the contract documents.

1.13 Project Record Drawings

- A. Refer to General Conditions for contractual requirements. Provide project record drawings as required by the General Provisions of the specifications and as required herein. Such drawings shall fully represent installed conditions, including actual locations of outlets, true panelboard connections following phase balancing routines, correct conduit and wire sizing as well as routing, revised fixture schedule listing the manufacturer and products actually installed and revised panel schedule. All changes to drawings shall be made by qualified draftspersons to match existing linework and lettering as close as possible. When all the changes have been made to the trade drawings, contractor shall produce one (1) full-size (E-size) updated set of trade drawing(s) utilizing AutoCAD 2000 or newer and supply one (1) set of compact discs (CDs) reflecting same.

1.14 Maintenance and Operating Instructions

- A. Furnish to the engineer four (4) hardback three-ring binders containing all bulletins, operating and maintenance instructions, part lists and other pertinent information for each and every piece of equipment furnished under this specification. Include service telephone numbers. Each binder shall be indexed into sections and labeled for easy reference. Bulletins containing more information than the equipment concerned shall be properly stripped and assembled.
- B. At the time of completion, a period of not less than eight (8) hours shall be allotted by the contractor for instruction of building, operating and maintenance personnel in the use of all systems. All personnel shall be instructed at one time, the Contractor making all necessary arrangements with manufacturer's representative. The equipment manufacturer shall be requested to provide product literature and application guides for the user's reference. Costs, if any, for the above services shall be paid by the contractor.

1.15 Warranties

- A. Furnish to the engineer four (4) hardback three-ring binders containing all warranties of every piece of equipment furnished under this specification.

Include terms and limitations of warranties, contact names, addresses and telephone numbers of manufacturer. Each binder shall be indexed into sections and labeled for easy reference for each equipment warranty.

1.16 Extra Materials

- A. See Section 01600, Product Requirements, for additional provisions.
- B. All special tools for proper operation and maintenance of the equipment provided under this section shall be delivered to the District's representative

PART 2. PRODUCTS

PART 3. EXECUTION

3.01 Workmanship

- A. Preparation, handling and installation shall be in accordance with manufacturer's written instructions and technical data particular to the product specified and/or accepted equal except as otherwise specified. Coordinate work and cooperate with others in furnishing and placing this work. Work to reviewed shop drawings for work done by others and to field measurements, as necessary, to properly fit the work.
- B. Conform to the National Electrical Contractors Association "Standard of Installation" for general installation practice.

3.02 Installation

- A. Install in accordance with manufacturer's instructions.

SECTION 16050 – BASIC MATERIAL AND METHODS

PART 1. GENERAL

1.01 Section Includes:

- A. Conduit, raceways and fittings.
- B. Wires and Cables for 600 volts and less.
- C. Wire connections and devices.

- D. Outlet boxes.
- E. Pull and junction boxes.
- F. Disconnect switches and fuses.
- G. Supporting devices.
- H. Identifying devices.
- I. Grounding and bonding.

1.02 References

- A. NECA (INST) – Standard of Installation; National Electrical Contractors Association.
- B. NFPA 70 – National Electrical Code, latest edition.

1.03 Submittals

Submit in accordance with the requirements of Section 01300 the following items:

- A. A list of conduit types indicating where each type of conduit will be used. Indicate conduit manufacturers and fittings to be used.
- B. Wires and cables.
- C. Wiring devices and plates.
- D. Nameplates, including engraving schedules where engraved plates are specified.
- E. Fused disconnect switches.

1.04 Quality Assurance

- A. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.05 References

- A. ANSI C80.1 – Rigid Steel Conduit, Zinc Coated; 1995.
- B. ANSI C80.3 – Electrical Metallic Tubing, Zinc Coated; 1995.
- C. ANSI C80.5 – Rigid Aluminum Conduit; 1995.
- D. NECA (INST) – Standard of Installation; National Electrical Contractors Association; 1993.
- E. NEMA FB 1 – Fittings, Cast Metal Boxes and Conduit Bodies for Conduit and Cable Assemblies; 1993.
- F. NFPA 70 – National Electrical Code, latest edition.

PART 2. PRODUCTS

2.01 Conduit, Raceways and Fittings

- A. Rigid Steel Conduit
 - 1. Rigid steel conduit shall be full weight, pipe size, be finished inside and out by hot-dip galvanizing after fabrication, and conform with ANSI C80.1 and UL.
 - 2. Couplings shall be electroplated steel.
 - 3. Insulating Bushings: Threaded polypropylene or thermo-setting phenolic rated 150° C minimum.
 - 4. Insulated Grounding Bushings: Threaded cast malleable iron body with insulated throat and steel "lay-in" ground lug with compression screw.
 - 5. Insulated Metallic Bushings: Threaded cast malleable iron body with plastic insulated throat rated 150° C.
 - 6. Running threads are not acceptable.

B. Electrical Metallic Tubing (EMT)

1. Conduit: Conduit shall be formed of cold rolled strip steel and shall comply with ANSI C80.3 and UL requirements.
2. Couplings: Electroplated steel, UL-listed rain and concrete tight through 1-1/4" trade size. All EMT fittings shall be compression type.
3. Connectors: Steel, gland compression type with insulated plastic throat, 150° C temperature rated. All EMT fittings shall be compression type.

C. Liquid Tight Flexible Metal Conduit

1. Conduit: Conduit shall be fabricated in continuous lengths from galvanized steel strip, spirally wound. Flexible conduit, except where installed in concealed dry locations, shall be liquid tight with plastic jacket extruded over the outer zinc coating. No aluminum substitute will be accepted.
2. Fittings: Connectors shall be the screw clamp on screw-in (Jake) variety with cast malleable iron bodies and threaded male hubs with insulated throat or insulated bushings. Set screw-type connectors are not acceptable. Liquid-tight fittings shall be of cadmium-plated cast malleable iron with insulated throat.

2.02 Wiring and Cables

- A. Acceptable Manufacturers: CABLEC, Triangle or equal.
- B. Conductor Material: All wire and cable shall be insulated, stranded copper conductors. Soft drawn annealed copper wire, 98 percent conductivity, bearing the UL label.
- C. Minimum Conductor Size: AWG No. 12 for all power and lighting branch circuits. AWG No. 14 for all signal and control circuits.
- D. Color Coding: System conductors shall be identified as to voltage and phase connections by means of color-impregnated insulation or approved colored marking tape as follows:

E. For 120/208-volt, 3-phase, 4-wire systems:

1. Phase A – Black
2. Phase B – Red
3. Phase C – Blue
4. Neutral – White
5. Ground – Green

F. Secondary Wire and Cable (0 to 600 Volts):

1. NEC Type THWN, or Type XHHW for feeders and branch circuits in wet or dry locations. NEC Type THHN for branch circuits in dry locations.

2.03 Wire Connection

- A. Wire Joints: Wires in sizes from No. 18 to No. 8 AWG, stranded conductor, with insulation rated 105° C. or less shall be joined with electrical spring connectors of three-part construction incorporating a nonrestricted, zinc-coated steel spring enclosed in a steel shell with an outer jacket of vinyl plastic with a flexible insulating skirt.
- B. Mechanical Compression Connectors and Taps: Stranded conductors from No. 6 AWG to 750 Kcmil shall be joined or tapped using bolted pressure connectors having cast bronze compression bolts. Fittings shall be wide range-taking and designed to facilitate the making of parallel taps, tees, crosses or end-to-end connections. Split-bolt connectors will not be acceptable.
- C. Fixture Connections: Splice fixture wire to circuit wiring with solderless connectors as specified above in Paragraph A.
- D. Terminating Lugs: Conductors from size No. 6 AWG to 750 MCM, copper, shall be terminated using tin-plated hydraulically operated crimping tools and dies as stipulated by the lug manufacturer. Lugs shall be 3M "Scotchlok" Series 30014, Burndy Type Ya-L Series, or equal.
- E. Splicing and Insulating Tape (600 volts and below): General purpose electrical tape shall be suitable for temperatures from minus 18° C to 105° C;

be black; be ultraviolet proof; and be self-extinguishing, 7 mil thick vinyl with a dielectric strength of 10,000 volts. Apply four (4) layers half-lap with 2" over-lap on each conductor.

- F. Insulating Putty (600 volts and below): Pads or rolls of noncorrosive, self-fusing, 1/8" thick rubber putty with PVC backing sheet. Putty shall be suitable for temperatures from minus 17.8° C to 37.8° C and shall have a dielectric strength of 570 volts/mil minimum.
- G. Insulating Resin: Two part liquid epoxy resin with resin and catalyst in premeasured, sealed mixing pouch. Resin shall have a setup time of approximately 30 minutes at 21.1° C and shall have thermal and dielectric properties equal to the insulation properties of the cables immersed in the resin.
- H. Terminal Strip Connectors: Terminate wire in locking tongue style, pressure type, solderless lug, where applicable.

2.04 Wiring Devices

- A. Switches: Specification grade, flush mounting, quite operating AC type, with toggle operator, heat resistant plastic housing and self-grounding metal strap. Silver or silver alloy contact. Rated 20A at 120-277V and capable of full capacity on tungsten or fluorescent lamp load. Design for up to No. 10 wire. Use single pole, double pole, three-way, four-way, lighted, pilot or keyed type, as indicated on drawings or required. Provide ivory color unless otherwise noted. Manufacturer: Leviton, Arrow Hart or Hubbell.
- B. Receptacles: Specification grade, flush-mounting receptacles with nylon face. High-grade brass allow triple wipe contacts. Provide 2-pole, 3-wire grounding type with a green-colored brass hexagonal equipment grounding screw. Grounding shall be rivetless, single piece brass with no mechanical connections in the primary path between point of ground wire termination and ground blades. Use 20A-rated receptacles, ivory in color, unless otherwise noted. Manufacturer: Leviton, Arrow Hart or Hubbell.
 - 1. Isolated Ground – Provide separate path to ground with orange faceplate or triangle to indicated isolated ground.
 - 2. GFCI – Equipped with diagnostic indicator for miswiring.
 - 3. Weatherproof – GFCI type, outdoor rated, with while-in-use cover

- C. Faceplates: Provide nylon cover faceplates for wall receptacles, outlets and switches. Include thermal mounting screws that match plate and device color. Manufacturer: Leviton, Arrow Hart or Hubbell.

2.05 Outlet Boxes

- A. Standard Outlet Boxes: Galvanized, die formed or drawn steel, knock-out type of size and configuration best suited to the application indicated on the plans. Minimum box size, 4" square by 1-1/2" deep, indoor use. FS cast boxes are required for outdoor use.
- B. Cast Metal Outlet Boxes: FS cast boxes are required for outdoor use. Four-inch (4") round, galvanized cast iron alloy with threaded hubs and mounting lugs, as required. Boxes shall be furnished with cast cover plates of the same material as the box and neoprene cover gaskets. Thomas and Betts, Crouse-Hinds VXF Series, Appleton JBX series or equal.
- C. Conduit Outlet Bodies: Cadmium-plated, cast iron alloy. Obround conduit outlet bodies with threaded conduit hubs and neoprene gasketed, cast iron covers. Outlet bodies shall be used to facilitate pulling of conductors or to make changes in conduit direction only. Splices are not permitted in conduit outlet bodies. Thomas and Betts, Crouse Hinds Form 8 Condulets, Appleton Form 35 Unilets or equal.

2.06 Pull and Junction

- A. Sheet Metal Boxes: Use standard outlet or concrete ring boxes wherever possible, otherwise use minimum 15-gauge sheet metal, NEMA 1 boxes sized to code requirements with covers secured by cadmium-plated machine screws located 6" on centers. Circle AW Products, Hoffman Engineering Company or equal.
- B. Cast Metal Boxes: Use standard cast malleable iron outlet or device boxes wherever possible, otherwise use cadmium-plated, cast malleable iron junction boxes with bolt-on, interchangeable conduit hub plates with neoprene gaskets. Appleton RS Series; Crouse Hinds RS Series or equal.

2.07 Disconnect Switches

- A. All disconnect switches shall be heavy-duty type and have the number of poles, voltage rating and horsepower rating as required by the motor or equipment. Disconnect switches shall be in enclosures to suit conditions —

NEMA 3R for outdoor and NEMA 1 for indoor. Disconnect switches shall be fused unless otherwise noted on the drawings. As manufactured by Square D – Class 3110, ITE Seimens or equal.

2.08 Fuses

- A. Dual Element, Time Delay, UL Class RK5. Rejection type. Size and voltage as indicated on equipment. Bussman, Little Fuse or approved equal.

2.09 Electrical Supporting Devices

- A. Concrete Fasteners: Phillips "Red-Head" or equal, self-drilling expansion-type concrete anchor.
- B. Conduit Straps: Hot-dip galvanized, cast malleable iron, two-hole type strap with cast clamp-backs and spacers as required. OZ/Gedney No. 14-50G strap and No. 141G spacer, Efcor No. 231 strap, and No 131 spacer or equal.
- C. Construction Channel: 1-1/2" by 1-1/2" 12-gauge galvanized steel channel with 17/32" diameter bolt holes, 1-1/2" on center, in the base of the channel. Kindorf 905 Series, Unistrut P-1000-HS or equal.
- D. Cable Ties and Clamps: Thomas and Betts Company "Ty-Raps" Panduit "Pan-Ty" or equal one-piece, nylon reusable-type lashing ties.
- E. Fasteners (General) : Wood screws for fastening to wood. Machine screws for fastening to steel. Toggle bolts for fastening to hollow concrete block, gypsum board or plaster walls. Expansion anchors for attachments to pre-poured concrete.

2.10 Identifying Devices

- A. Nameplates, Type NP: Engraved black bakelite, 1" by 3-1/2", 1/8" high white letters, machine screw retained. For permanent identification of all switchboards, panelboards, circuit breakers in separate enclosures, motor starters, relays, time switches, disconnect switches and other cabinet-enclosed apparatus, including terminal cabinets, or match existing as closely as possible.
- B. Legend Plates, Type LP: Die-stamped metal legend plate with mounting hole and positioning key for attachment to panel-mounted operators' devices. Engraved paint-filled characters as specified.

- C. Wire and Terminal Markers: Self-adhering, preprinted vinyl with self-laminating wraparound strip. Markers shall be legible after termination. Brady B191 Series, Thomas & Betts WSL series or equal.
- D. Conductor Phase Markers: Thomas & Betts WCPHAS Series or similar in addition to colored marking as specified under this section of the specifications.

2.11 Grounding and Bonding

- A. Ground Rods
 - 1. Manufacturer: Blackburn, Erico or approved equal.
 - 2. Size: 3/4" by 10' ground rods.
- B. Grounding electrode conductor, 2/0 for foundation foots and per NEC.
- C. Grounding Well – Christy Box, Valve Box.

PART 3. EXECUTION

3.01 Conduit and Raceway Applications

- A. Rigid Steel Conduit: For all exterior applications, all conduits larger than 2" trade diameter, indoor, below 8'.
- B. Electrical Metallic Tubing (EMT): Interior only and above 8' or when entering a panel from above.
- C. Liquidtight Flexible Metallic Conduit: In damp and wet locations for connections to motors, transformers, vibrating equipment and machinery. Connections to all pump motors, flow switches and similar devices.

3.02 Conduit Installation

- A. General
 - 1. All conduit runs shown on the plans are sized based on the use of rigid steel conduit and THWN copper conductors. If conductor type is changed, the contractor shall be responsible for resizing conduits to

meet code. In no case is conduit to be sized smaller than 3/4" trade diameter.

2. Low-voltage wiring shall be installed in conduit, minimum 3/4" trade diameter.
3. Conduits shall be tightly covered and well protected during construction using metallic bushings and bushing "pennies" to seal open ends.
4. In making joints in rigid steel conduit, ream conduit smooth after cutting and threading.
5. Clean any conduit in which moisture or any foreign matter has collected before pulling in conductors. Paint all field threaded joints to prevent corrosion.
6. In all empty conduits or ducts, install an 1,100-pound tensile strength polyethylene pulling rope.
7. Conduit systems shall be electrically continuous throughout. Install code size, uninsulated, copper grounding conductors in all conduit runs; grounding conductor shall be bonded to conduit, equipment frames and properly grounded.

B. Layout

1. All new conduits shall be concealed. Any field conditions that do not allow concealment of conduits shall be reviewed with the architect prior to rough-in.
2. Locations of conduit runs shall be planned in advance of the installation and coordinated with concrete work, plumbing and framing.
3. Where practical, install conduits in groups in parallel vertical or horizontal runs and at elevations that avoid unnecessary offsets.
4. Low-voltage conduit shall be grouped separately and labeled every 10' interval as to system (i.e. fire, control, etc.).
5. Exposed conduit shall be run parallel or at right angles to the centerlines of the columns and beams.

6. Conduits shall not be placed closer than 12" from a parallel hot water or steam line or 3" from such lines crossing perpendicular to the runs.
7. In long runs of conduit, provide sufficient pullboxes per NEC inside buildings to facilitate pulling wires and cables. Support pullboxes from structure independent of conduit supports. These pullboxes are not shown on the plans.

C. Supports

1. All raceway systems shall be secured to building structures using specified fasteners, clamps and hangers spaced according to code.
2. Support single runs of conduit using two-hole pipe straps. Where run horizontally on walls in damp or wet locations, install "clamp blocks" to space conduit off the surface.
3. Multiple conduit runs shall be supported using "trapeze" hangers fabricated from 3/8" diameter threaded steel rods secured to building structures. Fasten conduit to construction channel with standard two-hole pipe clamps. Provide lateral seismic bracing for hangers.
4. Installation
 - a. Locate and install anchors, fasteners and supports in accordance with NECA "Standard of Installation."
 - (1) Do not fasten supports to pipes, ducts, mechanical equipment or conduit.
 - (2) Do not drill or cut structural members.
 - b. Rigidly weld support members or use hexagon-head bolts to present neat appearance with adequate strength and rigidity. Use spring-lock washers under all nuts.
 - c. Install surface-mounted cabinets and panelboards with minimum of four (4) anchors.
 - d. In wet and damp locations, use steel channel supports to stand cabinets and panelboards 1" off wall.

- e. Use sheet metal channel to bridge studs above and below cabinets and panelboards recessed in hollow partitions.

D. Terminations and Joints

1. Raceways shall be joined using specified couplings or transition couplings where dissimilar raceway systems are joined.
2. Rigid conduit connection to enclosures shall be made by Myers-type grounding hubs only. EMT connections to enclosures shall be made with compression connector with grounding lock-nuts or bushings.
3. Conduit terminations exposed at weatherproof enclosures, and cast outlet boxes shall be made watertight using appropriate connectors and hubs.
4. Install expansion couplings where any conduit crosses a building separation or expansion joint.
5. Install cable sealing bushings on all conduits originating outside the building walls and terminating in switchgear, cabinets or gutters inside the building. Install cable sealing bushings or caulk conduit terminations in all grade-level or below-grade exterior pull, junction or outlet boxes.

E. Penetrations

1. Furnish and install metal sleeves for all exposed interior conduit runs passing through concrete floors or walls. Following conduit installation, seal all penetrations using noniron-bearing, chloride-free, nonshrinking, dry-pack grouting compound.
2. Install specified watertight conduit entrance seals and membrane clamps at all below-grade wall and floor penetrations. Conduits penetrating exterior building walls and building floor slab shall be insulated rigid steel.
3. Conduits penetrating rated walls, floors, etc. shall be fireproofed.

3.03 Cable and Wire Installation

A. Examination

1. Verify that interior of building has been protected from weather.
2. Verify that mechanical work likely to damage wire and cable has been completed.
3. Verify that raceway installation is complete and supported.
4. Verify that field measurements are as indicated.

B. Preparation

1. In existing conduits that will be reused, pull out existing conductors.
2. Completely and thoroughly swab raceway before installing wire.
3. Use 50/50 solution of Simple Green. Use CO₂ to blow water and soap into conduit; let soak to break up dried-out pulling compounds, then pull conductors. Pull one conductor at a time if all will not pull out together.

C. General

1. Conductors shall not be in conduit until all work of any nature that may cause injury is completed. Care should be taken in pulling conductors that insulation is not damaged. UL-approved nonpetroleum base and insulating type pulling compound shall be used as needed.
2. All cables shall be installed and tested in accordance with manufacturer's requirements and warranty.
3. Block and tackle, power driven winch or other mechanical means shall not be used in pulling conductors of size smaller than AWG No. 1.

D. Splicing and Terminating

1. All aspects of splicing and terminating shall be in accordance with cable manufacturer's published procedures.

2. Make up all splices in outlet boxes with connectors, as specified herein, with separate tails of correct color to be made up to splice. Provide at least 6" of tails packed in box after splice is made up.
3. All wire and cable in panels, control centers and equipment enclosures shall be bundled and clamped.
4. Encapsulate splices in exterior outlet, junction and pullboxes using insulating resin kits. All splices for exterior equipment in pump rooms shall be made up watertight.
5. Insulate mechanical compression taps AWG No. 1/0 and larger using premolded, snap-on insulating boots or specified conformable insulating putty overwrapped with two half-lapped layers of insulating tape.

E. Identification

1. Securely tag all branch circuits, noting the purpose of each. Mark conductors with vinyl wraparound markers. Where more than two (2) conductors run through a single outlet, mark each circuit with the corresponding circuit number at the panelboard.
2. Color code conductors size No. 6 and larger using specified phase color markers and identification tags.
3. All terminal strips are to have each individual terminal identified with specified vinyl markers.
4. All identification shall be legible and readable after completion of installation.

3.04 Electrical Connections

- A. Make electrical connections in accordance with equipment manufacturer's instructions.
- B. Make conduit connections to equipment using flexible conduit. Use liquidtight flexible conduit with watertight connectors in damp or wet locations.
- C. Connect heat-producing equipment using wire and cable with insulation suitable for temperatures encountered.

- D. Provide receptacle outlet to accommodate connection with attachment plug.
- E. Provide cord and cap where field-supplied attachment plug is required.
- F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.
- G. Install disconnect switches, controllers, control stations and control devices to complete equipment wiring requirements.
- H. Install terminal block jumpers to complete equipment wiring requirements.
- I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.

3.05 Installation of Boxes

A. General

- 1. Leave no unused openings in any box. Install close-up plugs as required to seal openings.
- 2. Exposed outlet boxes and boxes in damp or wet locations shall be cast metal with gasketed cast metal cover plates.

B. Box Layout

- 1. Outlet boxes shall be installed at the locations and elevations shown on the drawings or specified herein. Make adjustments to locations as required by structural conditions and to suit coordination requirements of other trades.
- 2. Install junction or pullboxes where required to limit bends in conduit runs to not more than 360 degrees or where pulling tension achieved would exceed the maximum allowable for the cable to be installed. Consult wire and cable manufacturer.

3.06 Installation of Wiring Devices

A. General

1. Install all devices flushmounted unless otherwise noted on the drawings. Comply with layout drawings for general locations. Consult architect or owner for locations that have conflict with other devices or manner not suitable for installation. Avoid place devices behind open doors.
2. Align devices horizontally and vertically. Device plates shall be aligned vertically with tolerance of 1/16". All four edges of device plates shall be in contact with the wall surface.
3. Mounting height as indicated on the drawings and according to ADA requirements.
4. Install device plates on all outlet boxes. Provide blank plates for all empty, spare and boxes for future use.
5. Securely fasten devices into boxes and attach appropriate cover plates.
6. Caulk around edges of outdoor device plates and boxes when rough wall surfaces prevent raintight seal. Use caulking materials approved by architect/engineer.
7. Fireproof around opening of devices located or penetrating fire-rated construction assemblies.

B. Switches

1. Where switches are indicated to be installed near doors, corner walls, etc., mount not less than 2" and not more than 18" from trim. Verify exact location with architect or engineer prior to rough-in.
2. Coordinate the location of switches to ensure locations at the strike side of doors.
3. Furnish and install engraved legend of each switch that controls exhaust fans, motors, equipment systems, etc. not located within sight of the controlling switch.

4. Ganging of Switches – Provide barriers for switches of different phases and voltages. Otherwise switches shall be gauged in one faceplate.

C. Receptacles

1. Mount receptacles vertically with U-shaped ground position on bottom.
2. Do not combine GFCI-protected circuits with other circuits in the same raceway. Limit number of GFI protect circuits in any one raceway to a maximum of one (1) circuit.

D. Identification

1. Label all outlets and switches. Mark each wiring device where circuits and panel supply is derived from.
2. All identification shall be legible and readable after completion of installation.

3.07 Installation of Fuses and Disconnect Switches

- A. Fuses shall be installed where noted on plans. Sizes are based on design data provided by air conditioning manufacturer. Listed or labeled equipment must be in accordance with instructions included in the listing or labeling. Be sure to observe maximum branch circuit fuse size labels.
- B. Disconnect switches shall be mounted on the units. Coordinate with mechanical contractor to ensure switches are not mounted on a removable access panel.
- C. Label each disconnect fuse with equipment tag as indicated in the single line diagram or as directed.

3.08 Electrical Equipment Grounding

- A. Ground noncurrent carrying metal parts of electrical equipment enclosures, frames, conductor raceways or cable trays to provide a low impedance path for line-to-ground fault current and to bond all noncurrent carrying metal parts together. Install a ground conductor in each raceway system in addition to conductors shown. Equipment ground conductor shall be electrically and mechanically continuous from the electrical circuit source to

the equipment to be grounded. Size ground conductors per NEC 250-95 unless larger conductors are shown on the drawings.

- B. Grounding conductors shall be identified with green insulation, except where a bare ground conductor is specified. Where green insulation is not available, on larger sizes, black insulation shall be used and suitably identified with green tape at each junction box or device enclosure.
- C. Install metal raceway couplings, fittings and terminations secure and tight to ensure good ground continuity. Provide insulated grounding bushing and bonding jumper where metal raceway is not directly attached to equipment metal enclosure and at concentric knockouts.
- D. Motors shall be connected to equipment ground conductors with a conduit grounding bushing and with a bolted solderless lug connection on the metal frame.
- E. Conduit terminating in concentric knockouts at panelboards, cabinets and gutters shall have insulated grounding bushings and bonding jumpers installed interconnecting all such conduits and the panelboard cabinet, gutter, etc.
- F. Performance: Measure ground resistance, 25 ohms or less.

3.09 Bonding

- A. Bonding shall be provided to assure electrical continuity and the capacity to conduct safely any fault current likely to be imposed.
- B. Bonding shall be in accordance with NEC Article 250, Part G.

3.10 Workmanship

- A. Preparation, handling and installation shall be in accordance with manufacturer's written instructions and technical data particular to the product specified and/or accepted equal, except as otherwise specified. Coordinate work and cooperate with others in furnishing and placing this work. Work to reviewed shop drawings for work done by others and to field measurements as necessary to properly fit the work.
- B. Conform to the National Electrical Contractor's Association "Standard of Installation" for general installation practice.

3.11 Installation

- A. Install in accordance with manufacturer's instructions.

SECTION 01780—CLOSEOUT SUBMITTALS

PART 1. GENERAL

1.01 Section Includes

- A. Project Record Documents.
- B. Operation and Maintenance Data.
- C. Warranties and Bonds.

1.02 Submittals

- A. Project Record Documents: Submit documents to engineer with claim for final Application for Payment.
- B. Operation and Maintenance Data
 - 1. For equipment or component parts of equipment, put into service during construction and operated by owner; submit completed documents within ten (10) days after acceptance.
 - 2. Submit one (1) copy of completed documents fifteen (15) days prior to final inspection. This copy will be reviewed and returned after final inspection with engineer comments. Revise content of all document sets as required prior to final submission.
 - 3. Submit two (2) sets of revised final documents in final form within ten (10) days after final inspection.
- C. Warranties and Bonds
 - 1. For equipment or component parts of equipment, put into service during construction with owner's permission; submit documents within ten (10) days after acceptance.
 - 2. Make other submittals within ten (10) days after date of substantial completion, prior to final Application for Payment.

3. For items of work for which acceptance is delayed beyond date of substantial completion, submit within ten (10) days after acceptance, listing the date of acceptance as the beginning of the warranty period.

D. As-Built Drawings

1. Submit two (2) compact disks with electronic as-built drawings in AutoCAD 2000 or newer. Include all pen settings.
2. Submit two (2) opaque copies and one (1) reproducible original of drawings to engineer.

PART 2. PRODUCTS—NOT USED

PART 3. EXECUTION

3.01 Project Record Documents

- A. Maintain on-site one (1) set of the following record documents; record actual revisions to the work:
 1. Drawings.
 2. Addenda.
 3. Change orders and other modifications to the contract.
- B. Ensure entries are complete and accurate, enabling future reference by owner.
- C. Store record documents separate from documents used for construction.
- D. Record information concurrent with construction progress.
- E. Record Drawings: Legibly mark each item to record actual construction including:
 1. Field changes of dimension and detail.
 2. Details not on original contract drawings.

3.02 Operation and Maintenance Data

- A. For Each Product or System: List names, addresses and telephone numbers of subcontractors and suppliers, including local source of supplies and replacement parts.
- B. Product Data: Mark each sheet to clearly identify specific products and component parts and data applicable to installation. Delete inapplicable information.
- C. Drawings: Supplement product data to illustrate relations of component parts of equipment and systems to show control and flow diagrams. Do not use project record documents as maintenance drawings.
- D. Typed Text: As required to supplement product data. Provide logical sequence of instructions for each procedure, incorporating manufacturer's instructions.

3.03 Warranties and Bonds

- A. Obtain warranties and bonds executed in duplicate by responsible subcontractors, suppliers and manufacturers within ten (10) days after completion of the applicable item of work. Except for items put into use with owner's permission, leave date of beginning of time of warranty until the date of substantial completion is determined.
- B. Verify that documents are in proper form, contain full information and are notarized.
- C. Coexecute submittals when required.
- D. Retain warranties and bonds until time specified for submittal.

3.04 As-Built Drawings

- A. Prepare as-built drawings utilizing AutoCAD 2000 or later. Use nationally recognized drawing standards, including layer management and organization.
- B. Engineer will provide original design drawing files for starting point of as-builts.

- C. Drawings shall indicate actual installed location, elevation, orientation, size and features of all equipment and materials installed under this contract.
- D. Revise all sheets from the design drawings as required to reflect actual construction. This includes, but is not limited to, all diagrams, panel schedules, equipment schedules, controls points lists, floor plans, elevations, profiles and sequences.

LIBRARY HVAC REPAIR

City of Mountain View Bid Sheet

No.	Description	Qty.	Unit	Material	Labor		Total
1	60 HP VFD	1	ea				
2	50 HP VFD	1	ea				
3	30 HP VFD	1	ea				
4	20 HP VFD	1	ea				
5	Panelboard Doors	4	ea				
6	Johnson Controls R & R vfd Points	12	pts				
7	Co2 sensors	3	ea				
8	Building pressure sensors	1	ea				
9	Equipment Rental	1	lot				
10	General Conditions	1	lot				
11	Sales Taxes	1	lot				
	TOTAL						

Company

Signature

Date _____